Specification for Photolithographic Pattern Generator

Section 1.0 General Requirement

1.1 Scope.

This specification describes the minimum technical requirements and the minimum acceptable performance standards for a photolithographic pattern generator to be installed by the contractor at the Naval Research Laboratory (NRL), Washington, DC. This system will be used for high-resolution direct writing on various substrates, as well as mask making. The pattern generator must be suitable for rapid prototyping of 2D and 3D microstructures on substrates up to 6 inches square. The pattern generator will be placed in a multiple user facility and must provide ease of operation and safety to those in the facility.

1.2 Installation Site.

The contractor shall install the pattern generator in Bldg. 250, Naval Research Laboratory, Washington DC 20375, at a specific location to be designated by the government Technical Manager (TM). The NRL will be responsible for providing the necessary facilities at that location for the proper installation of the tool. The contractor shall provide a preinstallation guide (no later than 30 calendar days prior to delivery of system) indicating, in detail, all of the site requirements including but not limited to: environment (e.g. vibration, temperature, air flow, air quality), facilities (e.g. air, water, vacuum etc.), electrical, communication (e.g. telephone, ethernet), workstation, space required and procedures for receiving the equipment. The contractor shall install the system in a manner consistent with typical clean-room operating procedures**.**

1.3 Description and Primary System Components

The photolithographic pattern generator will be used as a high precision instrument using raster technology to image on various substrates such as silicon, glass, film, or other photosensitive type plates. The pattern generator must be capable of patterning photosensitive polymers for the fabrication of semiconductor masks, integrated optics, electrical leads, biosensor electrodes, bond pads, shadow masks, micro electromechanical systems (MEMS), bioMEMS and devices for any application where high precision, high resolution images must be produced. Examples of standard photopolymers which the tool must be able to expose are: Clariant broadband g & i-line resists & Shipley 1800 series resists.

The system must be composed of at least the following major components:

- 1.3.1 movable media and fixed optics insuring that the optical path remains constant
- 1.3.2 a precise position computer controlled measurement system
- 1.3.3 a high-speed computer controlled positioning control system
- 1.3.4 a high accuracy beam position control.
- 1.3.5 high integrity robust mechanical structure

1.3.6 laser light source
1.3.7 high quality optics
1.3.8 data conversion computer & software

Section 2.0 System Requirements

2.1 Housing
The entire system must have a metal cover housing for light and dust protection.

2.2 Support system
The support system must have a heavy mass with air cushions for vibration isolation.

2.3 Light source
Light source must consist of a low noise air-cooled helium cadmium laser suitable for resist exposure.
The laser output power must be at least 70mW (with fast scan option) and 20mW standard.
Output measured at 442nm.
Lifetime of laser must be > 4000 hours.

2.4 Optics
Optics must consist of a lens system with highly reflective mirrors and an acousto-optic modulator system for intensity control.

2.5 Stage System

A high precision stage system consisting of the following components is required:

2.5.1 XY stage with linear motors capable of handling wafers of at least 6” diameter.
2.5.2 Active write area must be at least 140mm x 140mm.
2.5.3 Positional resolution must be equal to or less than 10nm.
2.5.4 Stage speed must be adjustable from at least 1mm/sec to 100mm/sec.
2.5.5 Stage must be equipped with a wafer/mask chuck designed for single plates.
2.5.6 Stage must use an interferometric or equivalent positioning system.

2.6 Writing system
The system must be capable of exposing a variety of feature sizes such that the write time will be as short as possible for a given area. That is, the write grid must be capable of being made larger with increasingly larger pattern sizes. A series of write grids falling within the ranges indicated in Table 1 must be provided. If only one lens can be used at any one time, the change from one lens to another must take a minimal amount of time.

The write grids must be provided by write heads equipped with an airguage or equivalent autofocus system.

The following table lists the specifications that must be met for the write grids indicated.

Table 1

Write Grid range	18-22 nm	38-42nm	98-102nm	195-205nm	390-410nm
Depth of Focus	≥ 0.6µm	≥ 1.7µm	≥ 8µm	≥ 35µm	≥ 140µm
Orthogonality	≤ 1.5µrad	≤ 2µrad	≤ 2µrad	≤ 2µrad	≤ 2µrad
Minimum feature size	≤ 0.6µm	≤ 0.8µm	≤ 2.0µm	≤ 4.0µm	≤ 8.0µm
Overlay Accuracy	≤ 150nm	≤ 200nm	≤ 500nm	≤ 1000nm	≤ 2000nm
Position Accuracy	≤ 400nm	≤ 600nm	≤ 1000nm	≤ 1500nm	≤ 2000nm
Critical Dimension Uniformity (nm)	≤ 100	≤ 120	≤ 250	≤ 500	≤ 800
Line Width Uniformity (nm)	≤ 80	≤ 100	≤ 220	≤ 440	≤ 880

2.7 Electronics

The electronic parts must be located in an external rack and must contain at least the following components:

2.7.1 An operating system. This must include the full software for controlling the system and the exposure process.

2.7.2 Multi-processor system controller

2.7.3 A SCSI hard disk with a capacity of at least 18GB

2.7.4 A pixel generator

2.7.5 System software for hardware control

2.7.6 Network software TCP/IP

2.7.7 Real time software for data decompression and exposure control

2.7.8 Alignment and Metrology software (if the option is selected – paragraph 7.1).

2.8 Operator menu

The Operator menu must run under windows based operating system and must include a system control menu that will provide the user with an easy interface to set up the job deck and run the metrology (if the option is selected) or diagnostic functions.

2.9 Control PC

The control PC must have a processor capable of operating the system. It must have a flat panel color monitor of at least 17" and function in a windows operating system.

2.10 Data conversion PC

A separate PC must be provided for Data Conversion. The PC must contain the latest Intel Pentium or equivalent processor and must have a color monitor of at least 17" and run under windows or equivalent operating system. It must have a hard drive with a capacity of at least 40 GB. The PC must be capable of being located remotely and connect to the pattern generator via an ethernet port.

2.11 Data conversion software

In order for the tool to accommodate the largest number of NRL researchers, the data conversion software must be capable of handling at least the following formats:
CIF (common intermediate format), GDSII (graphic design system), Gerber, and DXF (data exchange format).

Must have conversion software. The conversion software must provide a graphical interface with at least the functions of image reversal (positive /negative), biasing, scaling, and estimated write time.

2.12 System software

A backup copy of all of the system software is required.

2.13 System Controller

The system controller must have a multi-processor system. This must include the full software for controlling the system and the exposure process. This includes:

2.13.1 System software for hardware control
2.13.2 Network software TCP/IP
2.13.3 Real time software for data decompression and exposure control
2.13.4 Alignment and Metrology software (if the option is selected)

Section 3.0 Acceptance Criteria

In order to insure that the pattern generator meets the required specifications the contractor at time of installation shall demonstrate the machine's capability/functions. Using wafers provided by the NRL and prepared as required, contractor must verify specifications for the smallest write grid range stated in Table 1. Measurements may be made with the tool metrology and alignment option (if selected) or with an appropriate metrology tool provided by the NRL.

Section 4.0 Installation and Training

The contractor shall install the system at NRL-DC. The contractor must provide at least 3 days of training (functionality and how to operate system) for at least three NRL representatives at NRL-DC.

Section 5.0 Warranty

The contractor shall provide a twelve (12) month commercial warranty beginning the day after government acceptance.

Section 6.0 Documentation

The contractor shall provide all documentation, drawings and schematics for full site preparation, operation, troubleshooting, servicing and repair of the system and its components.

Section 7.0 Optional Items

The government may consider the following options.

7.1 **Option I** -- Metrology and Alignment System

The contractor shall provide a metrology and alignment system for multi-layer exposures and metrology measurements. The system must include at least the following components/capabilities:

- 7.1.1 Image Processing
- 7.1.2 Camera system
- 7.1.3 White light illumination
- 7.1.4 Image software
- 7.1.5 Alignment and Metrology software

To inspect and measure plates and perform overlay alignment a camera unit must be comprised of a micro-camera and a macro-camera arrangement and use white light illumination. The cameras must be connected to a video image processing system offering at a minimum, metrology functions of overlay alignment, line-width measurement and distance measurement.

7.2 **Option II** – Stage

The contractor shall provide an 8-inch stage instead of the standard 6-inch stage. The active write area must be least 170mm x 185mm.

7.3 **Option III** -- Environment Chamber including Flow Box

The contractor shall provide a flow box to afford the environment of the system with laminar airflow, a constant temperature and clean air. The chamber must meet the following minimum specifications:

- 7.3.1 Adjustable air flow between (0.3 – 0.5m/s)
- 7.3.2 Temperature stability (at ±1°C outside the box): ±0.1°C
- 7.3.3 Air quality: Class 10

7.4 **Option IV** -- Backside Alignment

The contractor shall provide a front to backside alignment for direct write applications. The backside alignment must use a third camera method for image recognition and registration on the substrate backside.

7.5 **Option V** -- Fast Scan

The system must have a fast scanning mode to facilitate the pattern generator. A suitable method of increasing the exposure speed would be through a more sophisticated system of electronics, optics and software.

This option must be capable of reducing the time required to expose an 80mm by 80mm fully populated area of 2 micron sized features from the approximate 13 hours required by the standard system to no more than 2.9 hours.

7.6 **Option VI** -- Extended Warranty

The contractor shall provide an additional commercial warranty of 36 months for a total of 48 months.